

Host-plant records and illustrations of the larvae of 19 geometrid moth species from a montane rainforest in Ecuador (Lepidoptera: Geometridae)

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Abstract: In October and November 2000, larvae of 19 geometrid moth species were collected in a montane rainforest in the province Zamora-Chinchipe in South Ecuador (3°58'S, 79°05'W) between 1800 and 2300 m above sea level and successfully reared to adulthood. The larvae of 17 species are illustrated for the first time and host-plant records are presented. Approximately 31 further species failed to reach the adult stage. Most species were recorded from Asteraceae hosts. While the successfully reared ennomine species (12 species) exclusively fed on leaves, Larentiinae species (5 out of 6 species) and one Geometrinae species fed on inflorescences.

Wirtspflanzennachweise und Abbildungen von den Raupen von 19 Geometridenarten aus einem Bergregenwald in Ecuador (Lepidoptera: Geometridae)

Zusammenfassung: Die Raupen von 19 Geometridenarten wurden im Oktober und November 2000 in einem montanen Regenwald in der Provinz Zamora-Chinchipe in Süd-Ecuador (3°58'S, 79°05'W) zwischen 1800 und 2300 m ü.NN gesammelt und erfolgreich zu Imagines gezüchtet. Die Raupen von 17 Arten werden erstmals illustriert und ihre Wirtspflanzen dokumentiert. Etwa 31 weitere Arten erreichten nicht das Adultstadium. Die meisten Arten wurden an Asteraceen gefunden. Während die erfolgreich gezüchteten Ennominen-Arten ausschließlich an Blättern gefunden wurden (12 Arten), fraßen Larentiinen-Arten (5 von 6 Arten) und eine Geometrinen-Art an Blüten.

Introduction

The host-plant records available for herbivorous insects, such as the species-rich Lepidoptera and Coleoptera, are strongly biased towards temperate regions (HEPPNER 1991, FIEDLER 1998a, b, WAGNER 1998). This has serious implications for the interpretation of both evolutionary traits and the understanding of the functional role of herbivorous insects in tropical ecosystems. Moreover, the degree of host-specificity of herbivorous insects served as a fundamental factor in the estimation of the total global species number (e.g., ERWIN 1982, ØDEGAARD 2000, NOVOTNY et al. 2002).

In very few groups, such as butterflies, more is known about host-plant preferences of tropical species than in most other insect groups (ACKERY 1991, FIEDLER 1998a). In contrast, the life-cycles and host-plant associations of tropical nocturnal Lepidoptera are unknown in most cases, apart from relatively large and conspicuous species such as Sphingidae and Saturniidae (see, e.g., the database provided by JANZEN & HALLWACHS 2001).

The Geometridae are one of the three most species-rich families of Lepidoptera. Geometrid moths occur in every biogeographical region of the world, but with some 6450

described species, by far the greatest number has been found in the neotropical region (SCOBLE et al. 1995, SCOBLE 1999). However, ecology and morphology of their early stages are still largely unknown. BREHM (2002) reviewed host-plant records of 226 neotropical geometrid species, i.e. data are available for less than 4% of all described species of the region. Since geometrid moths appear to be a relatively habitat-specific group that is sensitive to environmental changes (e.g., INTACHAT et al. 1997), they are a promising model taxon for ecological studies, particularly in tropical regions (BREHM 2002 and references therein). A recent worldwide catalogue (SCOBLE 1999) and modern generic revisions (PITKIN 1996, 2002) facilitate reliable identification and classification.

In order to improve the knowledge of the early stages of neotropical geometrid moths, new host-plant information is contributed concerning species with a previously unknown life-cycle from a montane rainforest in South Ecuador.

Study area and methods

Larvae were sampled in the area of the Estación Científica San Francisco in the province Zamora-Chinchipe in South Ecuador (3°58' S, 79°05' W) at elevations between 1800 and 2300 m above sea level in October and November 2000. The area is covered with primary or moderately disturbed montane rainforest as well as with early successional stages after human disturbance. The composition of the vegetation and its structure in the study area were described by BUSSMANN (2001) and PAULSCH (2002), respectively. Sampling was performed by inspection of foliage (hand-collecting) as well as by beating of branches. Whilst the results of hand-collecting are considerably dependent on the experience of the investigator, the latter method is effective for dislodging free-living caterpillars (BASSET et al. 1997). Larvae were reared in plastic vials at room temperature under the natural day-night photoperiod regime. Fresh leaves or inflorescences were provided at least every other day. Photographs were taken for documentation purposes (Plate 1). Pupae were kept moist until moths hatched. Emerging adults were determined in the Zoologische Staatssammlung, Munich, and in The Natural History Museum, London, and will be deposited in Staatliches Museum für Naturkunde, Stuttgart. Host-plants were determined by specialists (J. HOMEIER, S. MATEZKI), and by the author in the Herbario Nacional, Quito, Ecuador. Taxonomy follows SCOBLE's (1999) catalogue and PITKIN's (2002) generic revision of the subfamily Ennominae.

Results and discussion

A total of 101 larvae were collected in the field. Thirty-three were reared to adults and belonged to 19 species (12 Ennominae, 6 Larentiinae, 1 Geometrinae, Table 1). None of these species had ever been reared before, so all records of host-plants and larval morphology are new to science. Twenty-seven additional larvae of these 19 species failed to reach the adult stage, but could be reliably associated. The remaining 41 individuals belonged to a maximum of 31 morphospecies of larvae, but it was impossible to determine these early stages due to the lack of literature.

Host-plant relationships

Plants of the family Asteraceae seem to play an important role as hosts for geometrid moths in the study area. Approximately one third of all species, including those which failed to hatch, were found on plants of this family. Asteraceae are one of the most species-rich plant families worldwide as well as in Ecuador (JØRGENSEN & LEÓN-YANEZ 1999). The highest species richness occurs at elevations above 2000 m, where nearly 300 species were recorded. Asteraceae appear to be of particular importance for the genus *Eupithecia* (see Table 1). Records of six species of *Eupithecia* from South Ecuador already form a significant contribution to the knowledge of this genus in the neotropical region (BREHM 2002). The other plant families utilised are illustrated in Figure 18. Monocotyledons and ferns were not represented, despite their species-richness and abundance in the habitats investigated (e.g., WERNER 2002). These numbers give a rough idea about the plant taxa used, but data is by no means comprehensive or representative. However, they support the hypothesis that neotropical geometrid moths virtually always feed on dicotyledonous host-plants, as do those from northern temperate regions.

All ennomine species fed on leaves while five out of six species of Larentiinae, *Eupithecia*, were recorded on inflorescences. In temperate regions, such resources are also often exploited by species of this genus (e.g., SKOU 1986, MCGUFFIN 1958). The only larva representing the subfamily Geometrinae was also recorded on flowering parts of its host plant. In captivity, many of the ennomine species preferred young and fresh leaves. In some cases, old and tough leaves appear to be inappropriate food, such as, for example, the needles of the gymnosperm tree *Podocarpus oleifolius*. A caterpillar of *Melanolophia reducta* (Ennominae) was found on young soft leaves of this tree (Table 1), but refused in captivity to accept any older needles. In four cases larvae were found on more than one plant species. Two species of *Eupithecia* were each recorded on Amaranthaceae and Asteraceae inflorescences (Table 1). Despite the use of at least two different plant families, both these species appear to be specialised towards the protein-rich substrate of flowering plant parts. One larva each, of *Ischnopteris* sp. near *chryses* (Ennominae), was recorded on plants of the two dissimilar and unrelated families Bignoniaceae and Grossulariaceae. Two larvae

of *Melanolophia reducta* were collected from plants of the families Asteraceae and Podocarpaceae, respectively. Since larvae of the last two moth species were recorded on at least two different plant families, both can be regarded as polyphagous. This is particularly evident in the latter case because gymnosperms as well as angiosperms were utilised. In most other cases, species might well be polyphagous, but this remains speculative as long as only single records are available. Potential polyphagy is supported by the fact that some of the ennomine species accepted surrogate food in captivity (species of the genera *Bonatea*, *Bryoptera*, *Isochromodes*, Table 1). Feeding behaviour in captivity has to be regarded with caution and must be recorded separately from field data (e.g. EBERT & RENNWALD 1993). However, it shows the physiological potential of the moths to be more polyphagous. In a review on available host plant records of neotropical geometrid moths, BREHM (2002) emphasised that on a higher taxonomic level (genera, tribes) many taxa appear to be rather polyphagous, although there are also some specialist feeders such as species of the ennomine tribe Palyadini, which feed almost exclusively on Myrsinaceae host-plants. Much more field data from the neotropical region is generally required in order to get a better understanding of the host-plant relationships of this large family of herbivorous insects.

Morphology and behaviour

Larval morphology could not be thoroughly investigated by analyses of larvae stored in alcohol because priority was given to rearing larvae to adults. Hence, photographs were taken and most species (17 out of 19) are illustrated here (Plate 1). All larvae showed the typical reduction to two pairs of prolegs on the abdomen and moved by “looping”. The most remarkable larva was that of *Melinodes subapicata* (Ennominae). It had conspicuous “tentacles” on the abdominal segments A2 and A3 that became erect when touched. When the larva was observed from above, it superficially resembled a “four-legged” beetle or spider. The ecological significance of these morphological adaptations are uncertain, but *Melinodes* larvae possibly mimic harmful arthropod species in order to escape predators such as insectivorous birds. A similar photograph of another caterpillar of an unidentified *Melinodes* species by H. KIDANO is provided on the internet by INBio (1999). The *Microxydia* species resembled a bird dropping in its appearance. All other caterpillars illustrated here were highly cryptic. Some of the *Eupithecia* species showed a remarkable resemblance to the inflorescences of their host-plants. Species of the genera *Herbita*, *Ischnopteris* and *Oxydia* all mimicked twigs. In particular, the last genus has impressively large caterpillars (the illustrated specimen of *O. agliata*: 70 mm). Photographs of other *Oxydia* species, as well as other geometrid species are provided on the internet by JANZEN & HALLWACHS (2001). The larvae of the genera *Certima* and *Sabulodes* hid in small webs spun between leaves of their host-plants.

Table 1: Species collected in October and November 2000 in the area of the Estación Científica San Francisco, Zamora-Chinchipe, Ecuador. **n** = number of individuals successfully reared, **P** = part of plant used: leaves, flowers, photograph available. * = plants which were accepted in captivity but which were not original host-plants. ** = on young leaves.

Moth taxon	Plant family	Plant species	n	P	ph
Ennominae Boarmiini					
<i>Bryoptera basisignata</i> WARREN, 1904	Unknown Fabaceae*	Unknown treelet <i>Trifolium repens</i> *	1	le	+
<i>Melanolophia reducta meridiana</i> RINDGE, 1964	Asteraceae Podocarpaceae	<i>Baccharis latifolia</i> <i>Podocarpus oleifolius</i> **	2	le	+
<i>Physocleora</i> sp.	Euphorbiaceae	<i>Alchornea</i> sp.	1	le	—
“Cratoptera-group”					
<i>Melinodes subapicata</i> WARREN, 1904	Asteraceae	<i>Pentacalia</i> sp. 1	1	le	+
Nacophorini					
<i>Ischnopteris</i> sp. near <i>chryses</i> DRUCE, 1893	Bignoniaceae Grossulariaceae	<i>Tabebuia chryses</i> ** <i>Escallonia paniculata</i>	2	le	+
Nephodiini					
<i>Bonatea viridilinea</i> WARREN, 1904	Urticaceae Asteraceae*	<i>Pilea</i> sp. herb Asteraceae treelet*	1	le	+
Ourapterygini					
<i>Isochromodes fraterna</i> WARREN, 1904	Urticaceae	Unknown herb	1	le	+
<i>Isochromodes palumbata</i> WARREN, 1904	Asteraceae*	Unknown treelet* (found while moulting)	1	—	—
<i>Oxydia agliata</i> GUENÉE, [1858]	Asteraceae	Unknown treelet	1	le	+
Unplaced genera					
<i>Certima lojanata</i> DOGNIN, 1892	Asteraceae	<i>Pentacalia</i> sp.	1	le	+
<i>Microxydia</i> sp. near <i>ruficoma</i> PROUT, 1910	Asteraceae	<i>Baccharis latifolia</i>	3	le	+
<i>Sabulodes thermidora</i> THIERRY-MIEG, 1894	Asteraceae	<i>Baccharis latifolia</i>	1	le	+
Larentiinae Eupitheciini					
<i>Eupithecia anita</i> WARREN, 1906	Asteraceae Amaranthaceae	<i>Baccharis latifolia</i> <i>Iresine diffusa</i>	5 1	fl fl	+
<i>Eupithecia penicilla</i> DOGNIN, 1901	Asteraceae	<i>Baccharis latifolia</i>	1	fl	+
<i>Eupithecia yangana</i> DOGNIN, 1899	Myricaceae	<i>Myrica pubescens</i>	2	le	+
<i>Eupithecia</i> sp. 01	Asteraceae Amaranthaceae	<i>Erato polymnioides</i> <i>Iresine diffusa</i>	1 1	fl fl	+
<i>Eupithecia</i> sp. 02	Asteraceae	<i>Baccharis latifolia</i> <i>Piptocoma discolor</i> <i>Mikania lanceolata</i>	1 1 1	fl fl fl	+
<i>Eupithecia</i> sp. 03	Asteraceae	<i>Baccharis macrantha</i>	1	fl	+
Geometrinae Nemoriini					
<i>Lissochlora cecilia</i> PROUT, 1912	Grossulariaceae	<i>Escallonia paniculata</i>	2	fl	+

Rearing failure and parasitism

As many as 70% of the 101 larvae collected in the field did not reach the adult stage. Fifty-nine percent of these larvae died due to starvation or from unknown causes although they were offered their host-plants. However, in some cases host-plants were unknown because larvae were found on dead branches while they moulted. Other causes are losses during transportation (14 %), handling accidents (8 %), parasitism (6 %), lost specimens (5 %), death as pupae (5 %), and moulting failures (3 %).

Parasitism was observed in six specimens in four geometrid species. Two of the geometrid species affected could not be identified because no adults could be associated with them. One species that fed on *Piper* sp. (Piperaceae) was parasitised by a tachinid parasitoid that also failed to hatch. The other might have been a *Eupithecia* species that was sampled from *Escallonia paniculata* (Grossulariaceae). It was parasitised by a Hymenopteran species. The remaining geometrids were *Eupithecia anita* (one caterpillar) and an unidentified species of the same genus (*Eupithecia* sp. 03, three caterpillars). Their para-

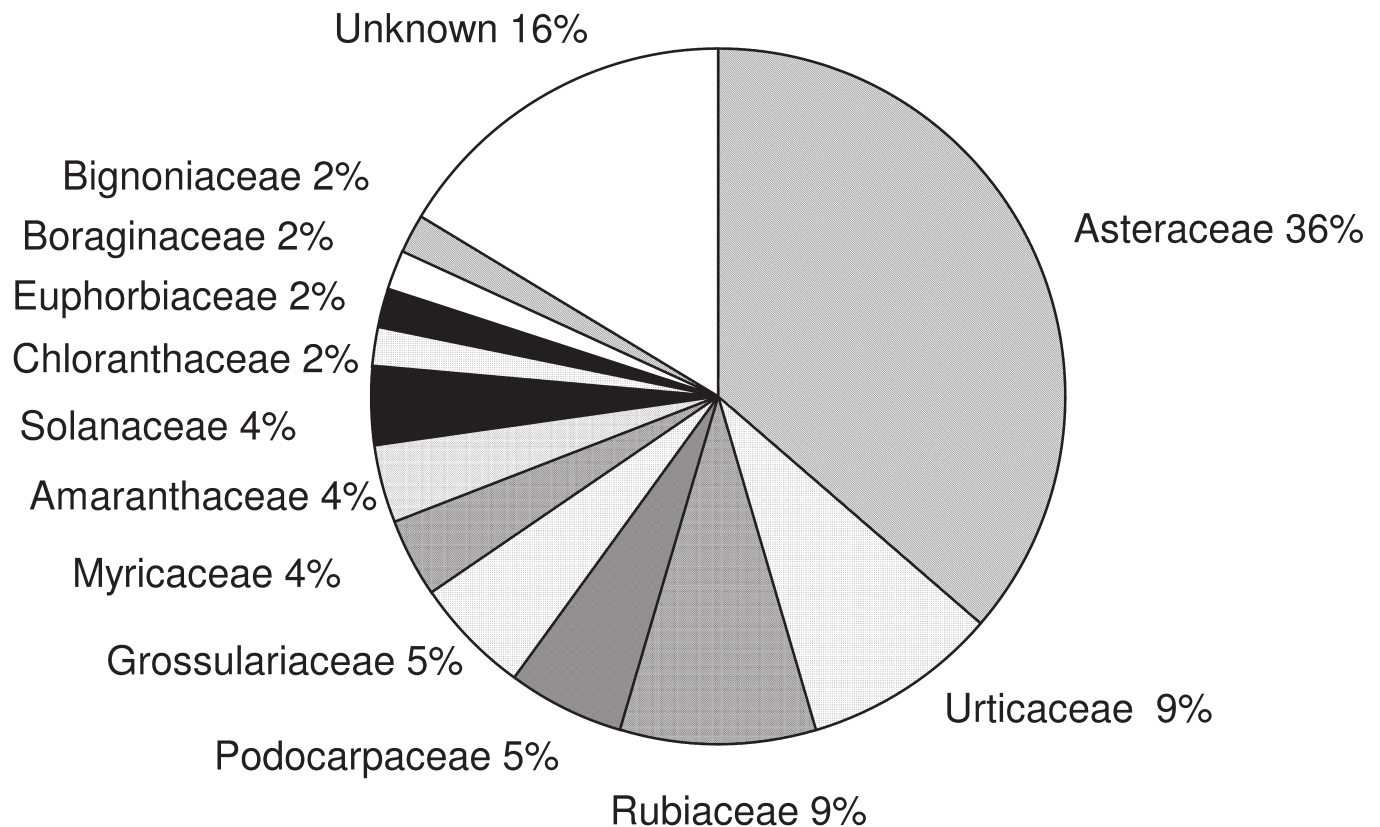


Fig. 18: Host-plant families used by geometrid moths in the area of the Estación Científica San Francisco, South Ecuador (1800–2300 m). Data is based on all species, including those “morphospecies” which failed to reach the adult stage (19 + 31 = 50). Species recorded on more than one host-plant were counted for each of their hosts.

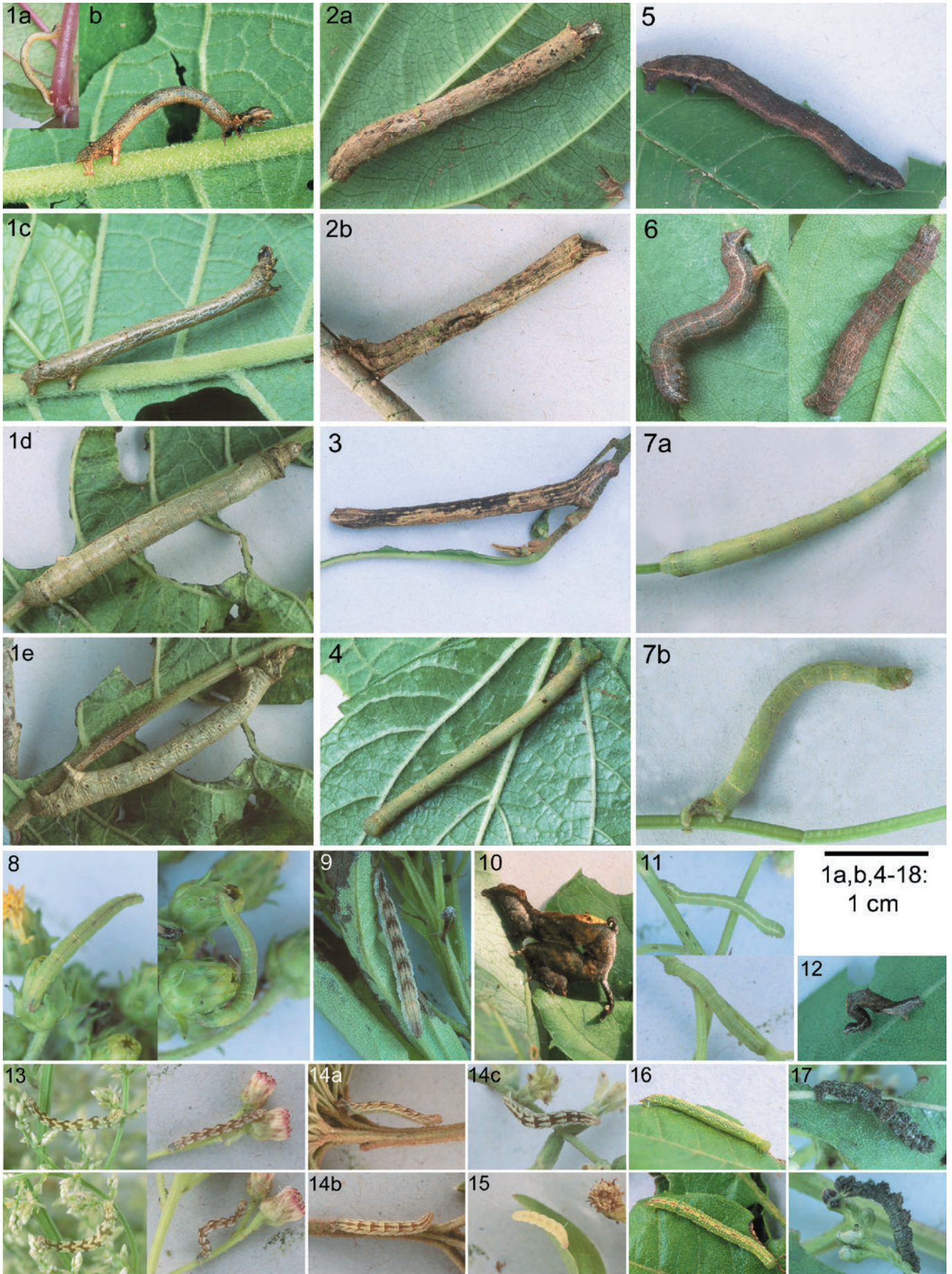
sites were also Hymenoptera and have not yet been identified. The number of parasitised species might actually have been greater because those larvae that died before pupation could also have been parasitised. Hence, the exact degree of parasitism is impossible to assess. Species richness of hymenopteran parasitoids in the tropics is generally believed to be relatively low (GAULD 1987, but see HORSTMANN et al. 1999). While very little is known about host-plant relationships of tropical moths, information about the role and species-richness of their parasitoids is even more limited. However, despite all these caveats, the paucity of incidences of parasitism among the sample of geometrid larvae considered here might well suggest that parasitoids are not as prevalent in montane Andean rainforests as they are in temperate-zone forests. Clearly, many more rearing data are required in order to reveal insights not only into these issues but also into general patterns of host-plant relationships of tropical herbivorous insects.

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Plate 1: Larvae of geometrid moths collected and successfully reared to adults from the area of the Estación Científica San Francisco, South Ecuador (1800–2300 m). All larvae except for number 1a–c are in their last instar (probably L_5) (1a: L_3 ; 1b, 1c: L_4). Figures 1a, 1b and 4–18 have the same scale (see the 1 cm bar in the figure). **Fig. 1:** *Oxydia agliata* (1c: 36 mm, 1d and 1e: 70 mm). **Fig. 2:** *Bonatea viridilinea* (44 mm). **Fig. 3:** *Ischnopteris* sp. near *chryses* (45 mm). **Fig. 4:** *Isochromodes fraterna*. **Fig. 5:** *Certima lojanata*. **Fig. 6:** *Sabulodes thermidora*. **Fig. 7:** *Bryoptera basisignata*. **Fig. 8:** *Eupithecia* sp. 01. **Fig. 9:** *Eupithecia penicilla*. **Fig. 10:** *Melinodes subapicata*. **Fig. 11:** *Melanolophia reducta* (young). **Fig. 12:** *Microxydia* sp. near *ruficomma*. **Fig. 13:** *Eupithecia anita*. **Figs. 14a–c:** *Eupithecia* sp. 02. **Fig. 15:** *Eupithecia* sp. 03. **Fig. 16:** *Eupithecia yangana*. **Fig. 17:** *Lissochlora cecilia*. — The corresponding host-plants are listed in Table 1.



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